

REMARKS

DETAILED ACTION

Action Items 1 and 2

2. Claims 1,3-5,7-10, 12-16, 18-20,22, 25-26,28, and 30 are rejected under 35 U.S.C. 103(a) as being unpatentable over Zhou et al. (6,358,842) in combination with Lou et al. (5,916,823).

The Examiner writes:

Zhou teaches a method to solve via poisoning for insulative porous low-k materials, see abstract, comprising the steps of: providing a silicon substrate, col.3, ln. 55-57, having a silicon nitride passivation layer with a thickness of 30-1000 Angstroms, col.4, ln.12-15, formed over a first metal layer formed on said substrate; fig.4, el.50, 58, and 54, forming a first insulative layer, with a thickness of 2000-100000 Angstroms, col.4, ln.49-52, over said substrate; el.62, forming a silicon nitride etch-stop layer, col.4, ln.60-63, with a thickness of 30-1000 Angstroms, col.4, ln.65-67, over said first insulative layer; el.66, forming a second insulative layer, with a thickness of 2000 to 100000 Angstroms, col.5, ln.34-37, over said etch-stop layer; el.70, forming a first photoresist layer over said second insulative layer and patterning said photoresist to form a first photoresist mask having a hole pattern; fig.5, el.78, etching said first and second insulative layers, including said etch-stop layer through said hole pattern to form a hole reaching said passivation layer; fig.5, removing said first photoresist mask; *forming a low-k protection layer over said substrate, including in said hole opening*; fig.6, el.82, forming a second photoresist layer over said substrate, including said hole opening and patterning said second photoresist to form a second photoresist mask having a trench pattern; fig.9, etching said second insulative layer through said trench pattern in said second photoresist mask to form a trench in said second insulative layer, thus completing the forming of said dual damascene structure in said substrate; fig. 10, *removing said second photoresist mask*; fig. 11, *removing said low-k protection layer from over said substrate and from the bottom of said hole opening and thereby exposing underlying said passivation layer while leaving said low-k protection layer on the vertical sides of said hole opening*; fig.6, el.82, removing said passivation layer from said bottom of said hole opening, thereby exposing underlying said first metal layer; fig. 7, el. 82, 86, forming a barrier layer over said substrate, including in said dual damascene structure; fig.13, el.104, wherein said barrier layer conforms to said low-k protective layer in said hole opening and conforms to said trench in said second insulative layer, col.8, ln.49-64, depositing a second metal, such as copper, over said barrier layer in said dual damascene structure; fig.13, el.106, and performing chemical mechanical polishing (CMP) to complete the forming of said dual damascene structure, col.8, ln.62-63. Further, Zhou teaches forming a low-k protection layer - comprises small amounts of SiO₂, SiN, SiC and SiNC, col.6, ln. 18-25, wherein said low-k protection layer has a thickness between about 20 to 1000 Å, col.6, ln.48-50, and wherein said barrier layer comprises Ta, Ti, TaN, TiSiN, TaSiN, WN, col.8, ln.56-58.

3. Zhou appears not to teach forming the low-k protection layer on the second

isolative layer, nor will the protection layer prevent outgassing from the first and second insulating layer, because Zhou only teaches small quantities of SiO₂ in the protective layer. Lou teaches forming the low-k protection layer on the second insulative layer, fig.5, el.128, col.3, ln.30-48, where the protection layer is composed of CVD oxide, col.3, ln.30-48, and having a thickness, col.3, ln.36-37, sufficient to prevent outgassing from the first and second insulating layer. It would be obvious to one of ordinary skill in the art at the time of the invention to combine Lou with Zhou to modify Zhou with an alternative protective layer material that also reduces outgassing as taught by Lou, col.3, ln.41-43, so as to further reduce via poisoning, Zhou, col.6, ln.32-34.

The Applicants respond:

The instant invention is not of a structure, but of a method which produces a different detailed structure. Likewise is Zhou and Lou.

The series of steps in the Zhou, the Lou and the instant methods are different although all produce a quite similar well known general dual damascene structure, typically a wide channel in the upper dielectric intersecting a smaller via in the lower dielectric. All are using some form of low-k material. All are using a silicon nitride etch stop layer.

As noted by the Examiner, Lou does use a CVD oxide on the walls of the damascene openings to prevent outgassing from both the upper as well as the lower dielectric layers. Zhou does the same using a sulfur based material. But a simple replacement of these steps of Zhou with that of Lou does not result in either same sequence of steps nor the same resulting structure of the instant invention.

What the Examiner appears to be saying is that Lou is an example of using CVD oxide on a low-k dielectric, especially in a via, and it prevents outgassing from a low-k dielectric. And further, one could substitute the single first photo resist stripping and via sulfur material coating step of Zhou with the double (CVD oxide step after photo resist stripping) step of Lou.

By this line of reasoning, is the Examiner suggesting that all of Zhou's two single photo resist stripping and sulfur material coating steps be replaced by CVD oxide coating steps after each of the two required photo resist stripping steps? If so, this does not read on the instant invention. The instant invention does not apply a low-k protection layer to the trench portion of the damascene structure.

By the same line of reasoning, is the Examiner suggesting that only the lower dielectric be coated with CVD oxide in the manner of Lou, but the upper dielectric be coated in the manner of Zhou? If so, this does not read on the instant invention. The instant invention does not use a sulfur resist stripping operation.

4. Zhou also teaches that the capping layer, el.74, is optional, col.5, ln.38-40. Therefore, combining Lou with that embodiment of Zhou which lacks the capping layer, a skilled artisan would be motivated to replace the sulfonating process of Zhou with the CVD process of Lou, thus forming the protection layer on the second insulating layer, as claimed.

The Applicants reply:

The instant step of coating the via walls with an oxide by a blanket style deposition incidentally coats the all the surfaces including the upper surfaces of the second dielectric. That coating on the second dielectric is removed during the step of removing the coating from the bottom of the via in a later step. This is descriptive of the process of the invention and distinguishes it from Zhou.

Lou indeed shows a CVD oxide over a second dielectric layer as well in the via hole (Fig. 5) and that CVD oxide is removed from over the second dielectric layer as well as from the bottom of the via hole during a spacer formation step (Fig. 6).

However, the Lou CVD oxide step occurs after the formation of both the first and second damascene openings, while the instant invention has the oxide coating occurring after forming the first openings but before forming the second openings in the upper dielectric.

Furthermore, the Lou CVD oxide step occurs after opening the passivation layer 104 thereby exposing the underlying metals to the low-k dielectrics during subsequent processing. This contrasts with the instant invention in which the passivation layer is not opened to the metals until the via has been coated with the oxide.

5. Claims 11 and 29 are rejected under 35 U.S.C. 103(a) as being unpatentable over Zhou and Lou as applied to claims 1, 3-5, 7-10, 12-16, 18-20, 22, 25-26, 28, and 30 above, and further in view of Lin (6,140,220). Lou fails to teach a barrier layer and Zhou appears not to specify the thickness of the barrier film, nor the etch chemistry used to etch the first and second insulators, the etch stop layer, and the protective layer. Lin teaches forming a barrier layer comprising Ta or TaN, having a thickness of 100-2000 Angstroms, col.4, ln.18-23. It would have been obvious to one of ordinary skill in the art at the time of the invention to combine Lin with Zhou to use a barrier layer of the same material with a thickness used by Lin to prevent via poisoning, thereby reducing contamination of the interconnect structure.

6. Claims 2, 6, 17, and 21 are rejected under 35 U.S.C. 103(a) as being unpatentable over Zhou and Lou as applied to claims 1, 3-5, 7-10, 12-16, 18-20, 22, 25-26, 28, and 30 above, and further in view of Eissa et al. (US2002/0127876). Zhou and Lou appear not to specify the k value of the low-k dielectric used in the first and/or the second dielectric. Eissa teaches the use of a low-k dielectric in a copper dual damascene interconnect structure having a k value between 2.0 and 3.0, page 1, par. [0010]. It would have been obvious to one of ordinary skill in the art at the time of the invention to select a low-k dielectric having a k-value between 2.0 and 3.0 in an interconnect structure having copper, in order to reduce the parasitic capacitance of the interconnect thereby reducing the RC constant and increasing the speed and performance of the devices.

The Applicants reply by saying that claims 2, 6, 11, 17, 21 and 29 are dependent on the respective independent claims

Allowable Subject Matter

7. Claims 23-24, and 27 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Applicant claims a specific combination of etch ants, specifically, C2F6, C4F3, Ar, N2, and O2, which are used to etch the porous low-k first and second insulative layers. Further, applicant asserts that the claimed particular gas combination is particularly effective in the etching of low-k insulative layers. In conclusion, the examiner has not found any art either singly or in combination that suggests that one of ordinary skill in the art at the time of the invention would have been able to anticipate and/or practice the claimed invention, without undue experimentation.

The Applicants decline this offer by the Examiner at this time because the Applicants have amended independent claim 13 and believe it now to be allowable and thus claims 23, 24 and 27 would also be allowable.

Response to Arguments

8. Applicant's arguments with respect to claims 1-30 have been considered but are moot in view of the new ground(s) of rejection. Examiner would like to point out that the language of claim 13 permits for the following sequence of removing the first resist, forming the second resist, etching the trench, removing the second resist, and forming the low-k protective layer, which is found in the Zhou and Lou combination.

The Applicants take notice of this possible reading and amend claim 13 to preclude such a reading. The following limitations of claim 13 now require the second photoresist to be applied over the low-k protection layer.

Claim 13....

forming a low-k protection layer in said hole opening in said first and second insulative layers, including over said substrate;

forming a second photoresist layer over said substrate, including over said hole opening having said low-k protection layer and patterning said second photoresist to form a second photoresist mask having a trench pattern;

Similarly claim 1 is amended to require the forming of the trench after coating the via with a low-k protection layer.

Claim 1....

forming a trench opening over said hole opening to form a dual damascene structure, said hole opening containing said low-k protection layer,

CONCLUSION

It is respectfully suggested that these various references cannot be combined without reference to applicants' own invention. It is believed that independent claims 1 and 13, and hence claims dependent from claim 1, and claims dependent from claim 13, as amended, are allowable, and we therefore request respectfully that Examiner Berezny reconsider these rejections in view of these arguments and the amendments and allow claims 1 through 30

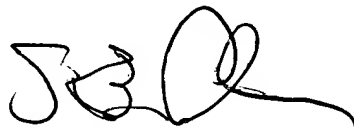
We have reviewed the related art references made of record and agree with the Examiner that none of these suggest the present claimed invention.

In light of the above arguments, it is suggested that the claims now clearly distinguish the invention from the prior art. All claims are therefore believed to be in condition for allowance.

Allowance of all claims is therefore respectfully requested.

It is request that should Examiner Berenzy not find that the Claims are now Allowable that the Examiner call the undersigned attorney at 845-452-5863 to overcome any problems preventing allowance.

Respectfully submitted,

A handwritten signature in black ink, appearing to read 'SBA', with a stylized flourish extending to the right.

Stephen B Ackerman, Reg. No. 37,761